Space Technology Research Grants

Flow Boiling and Condensation in Microgravity

Completed Technology Project (2015 - 2019)

Project Introduction

Due to its potential to improve system performance while reducing mass, space programs worldwide are considering the implementation of two-phase thermal management systems. By capitalizing on a fluid's latent heat as well as sensible, two-phase systems can offer vast improvements in both heat acquisition and rejection compared to their traditional single-phase counterparts. Before these systems can be implemented, however, an increase in both the quantity and quality of available design tools is necessary. These tools are critical for determining heat transfer coefficients, pressure drop, and critical heat flux (CHF) in flow boiling, all of which are integral to the design of thermal control systems. In particular, the impact of the different gravitational fields commonly seen in spaceflight on these defining characteristics isn't well understood. Many existing models show poor results when applied in microgravity, displaying the need for new predictive tools that can accurately capture system behavior in a broad range of gravitational environments. The proposed study will utilize the Purdue University Boiling and Two-Phase Flow Lab's (PU-BTPFL's) flow boiling and condensation rig, which can be operated both on the ground and in parabolic flight. By controlling the angle of descent, parabolic flights can be used to simulate a range of gravitational fields, including microgravity, Lunar gravity, and Martian gravity. In addition to gathering heat transfer data, flow visualization techniques will be employed to help capture and classify the different flow regimes encountered. These regimes have been shown to depend greatly on flow orientation for boiling and condensation, as well as heater orientation for flow boiling. These factors are again expected to play an important role in microgravity. The data gathered in different gravitational fields will be used to develop mechanistic models and advanced computational methods. These tools can then be applied to the design of advanced thermal management systems for space systems, helping to make the next generation of spacecraft both lighter and capable of handling devices with higher energy density than is currently possible. The technology developed by this study will primarily benefit NASA Technical Area (TA) 14, Thermal Management Systems. Specifically, TA-14.2, Thermal Control Systems, will see the greatest impact from this work. Because thermal control systems are integral components of so many different technologies, however, the work will also impact the development of more than half of the other specified technical areas (as shown in fig. 6 of NASA TA-14 document). Because of this potential to greatly influence the design of a broad range of technologies, the work done in this study towards the development of two-phase thermal control systems will have a significant impact on all future space missions.

Anticipated Benefits

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Table of Contents

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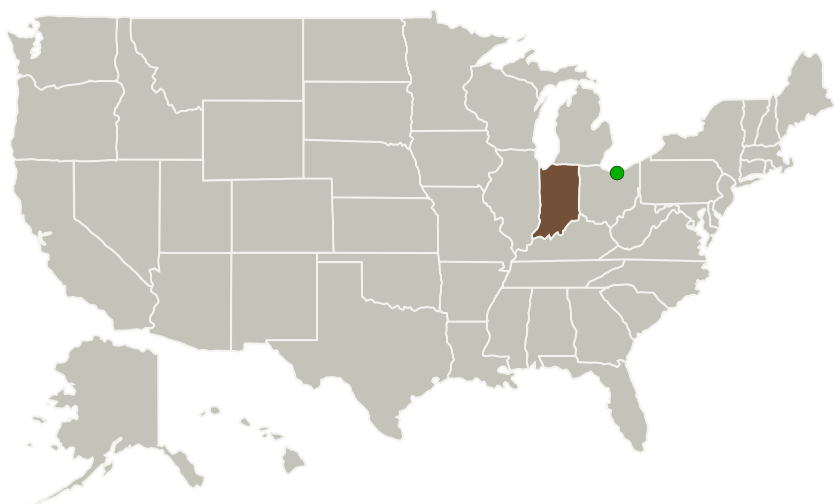
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Purdue University-Main Campus	Lead Organization	Academia	West Lafayette, Indiana
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations
Indiana

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Purdue University-Main Campus

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Issam Mudawar

Co-Investigator:

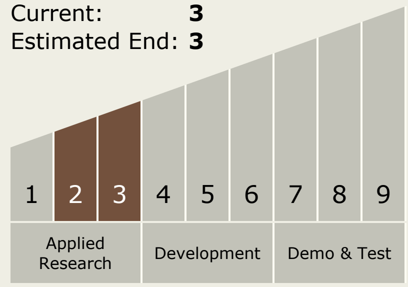
Lucas O'neill

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX14 Thermal Management Systems
  └ TX14.2 Thermal Control Components and Systems
    └ TX14.2.5 Thermal Control Analysis

Target Destinations

Earth, The Moon